Development of software-hardware complex for investigation of the vector field of speeds in the cyclone-separator

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Abstract. The current issue of studying the vector velocity field in a cyclone-separator with a screw insert is considered in the article. Modeling of the velocity vector field in SolidWorks was carried out, tangential, axial and radial velocities were investigated. Also, a software and hardware complex was developed that makes it possible to obtain data on the speed inside a cyclone separator. The results of the experiment showed that on flour dusts the efficiency of the cyclone separator in question was more than 99.5%, with an air flow rate of 376 m^3 / h, 472 m^3 / h and 516 m^3 / h, and ΔP less than 600 Pa. The velocity in the inlet branch of the screw insert was 18-20 m / s, and at the exit of the screw insert the airflow velocity is 50-70 m / s.

1 Introduction

Automation of technological processes is the basis in modern flour milling. Increasing labor productivity, ensuring the safety of production and personnel, increasing the yield of products is possible only with the use of an automatic control system. With the use of modern automation equipment, it is possible to extend the service life of the equipment by 10-15 years [1].

Federal laws "On Environmental Protection" of 10.01.2002 No. 7-FZ; No. 96-FZ of 04.05.1999 "On the Protection of Atmospheric Air" regulate the necessity and procedure for the use of gas purification facilities at sites that have a negative impact on the environment.

At present, cyclones are the basis for dedusting flour mills. For dry cleaning of large volumes of air inertia-gravitational dust separators (cyclones) are used. Their structural elements provide rotational or translational motion of the air flow.

In comparison with other types of dust separators, cyclones have the following advantages: simplicity of design, reliability; satisfactory efficiency, durability and maintainability; high throughput, as well as relatively low aerodynamic drags [2].

It should be noted that the real efficiency of air purification in cyclones under industrial conditions is much lower (of the order of 80%), which is due to various reasons; for example, it may be not fulfilling the condition of the matching of the input speed to the optimum value [3, 4].

The development of a cyclone separator on the basis of an air-screw insert located on the cyclone exhaust pipe and located in a confuser with a perforated surface made it possible to create a fundamentally new method [3], which has no analogues. In the laboratory, currently has an efficiency of 95-99.9%, which is higher than foreign analogs.

The aim of the work is the development of a software and hardware complex for the investigation of the vector velocity field in a cyclone-separator.

The tasks of the work include:

- to build and conduct research on the mathematical model in SolidWorks;
- develop a software and hardware system for the investigation of the vector velocity field;
- to carry out research on the experimental installation of the cyclone-separator with the help of the developed complex;
- compare the results obtained during the study.
- control over the movement of personnel and clients of the organization both inside and outside the building;
- obtaining data for information and analytical work.

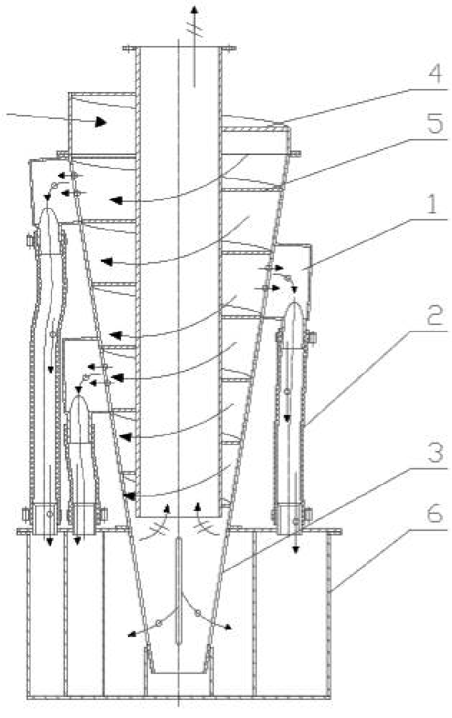
2 Principle of operation

To increase the efficiency of the cyclone, it is necessary to control its technical parameters, such as the degree of purification, the volume of air to be purified, and the pressure loss.

In most cases analogue, as well as portable digital devices are used for these purposes.

The disadvantages of analog devices include the accuracy, which affects the wear of moving parts and the human factor. Portable digital devices of these drawbacks are lacking, but the high price, the lack of simultaneous monitoring of the set of technical parameters, and in some cases the duration of measurements, make these devices unacceptable for continuous monitoring of parameters [4].

The functional diagram of the experimental dust separator is shown in Figure 1 [5, 6].



- motion of the raw air, - motion of clean air, - movement of dust.
1 - the box; 2 - flexible hose; 3 - attachment; 4 - snail; 5 - screw insert; 6 - container
Figure 1. Functional diagram of the experimental cyclone-separator.

The air mixture on the material conduit enters the input cochlear 4 of the experimental dust separator. The input snail serves to communicate the rotational axisymmetric motion to the product and thereby create conditions for the separation of the product from the stream. Exiting the swirler, the flow enters the conical part of the experimental dust separator and acquires additional rotary screw motion due to the screw insert 5.

Large particles of the product rush to the walls of the experimental dust separator due to the effect of the centrifugal force that occurs in the rotating stream, as a result of which their main mass enters the slot to catch large dust and precipitates in boxes located at different heights. The rest of the dust, along with the air, moves axially to the lower part of the dust separator, where, under the action of inertia, the dust gets into the cone-cone 3 for additional cleaning of the air, and the purified air leaves the exhaust pipe at the lowest resistance.

Changing the gap between the cochlea to which the screw insert is fixed, and the resistance of the dust separator changes with the outer cone. Within the acceptable limits, lifting the cochlea does not significantly change the efficiency of the dust removal.

To improve sealing, sealing gums are used, sealant on all mating parts of the dust separator.

3 Results of device testing

To study the vector velocity field in a cyclone-separator, a model was developed in SolidWorks [7] (Figure 2).

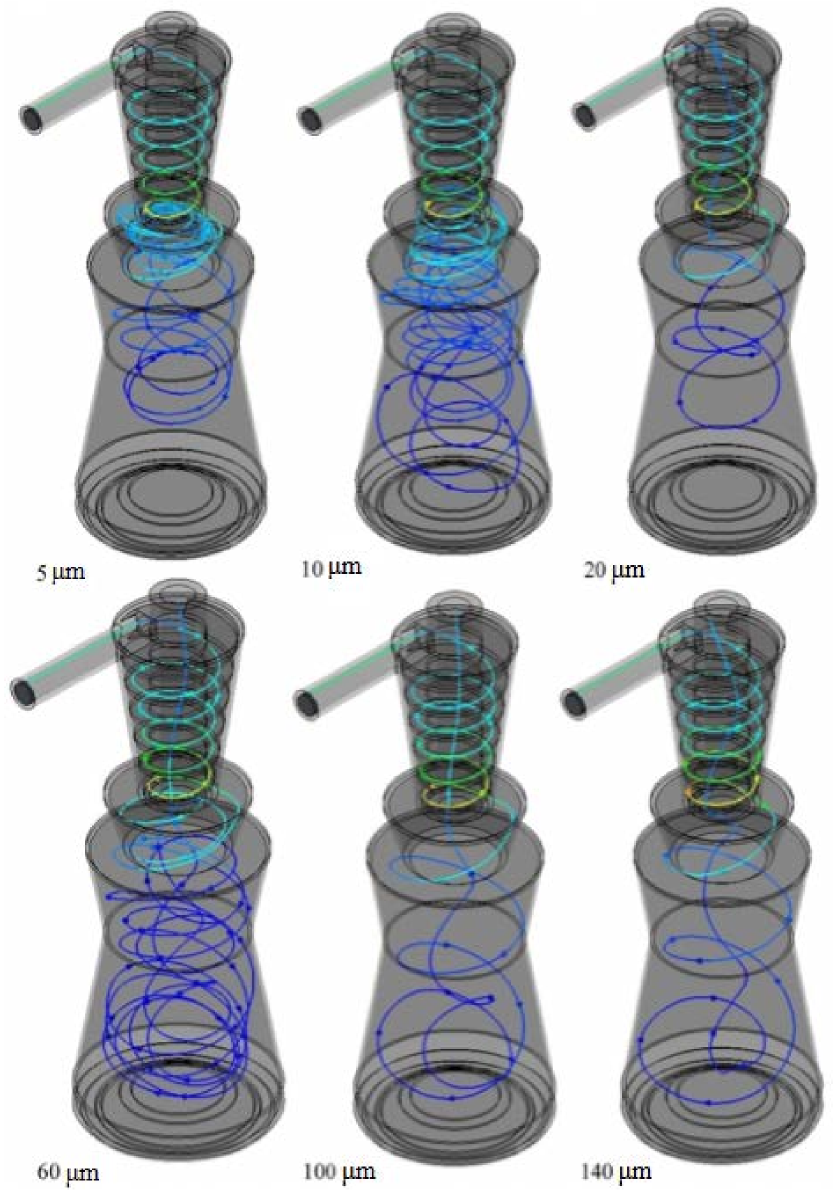


Figure 2. Dependence of the motion of particles of finely dispersed material in the apparatus.

It can be seen from Figure 2 that particles, due to a large radial velocity, push against the wall of the cone.

Figure 3 shows the change in radial velocity.

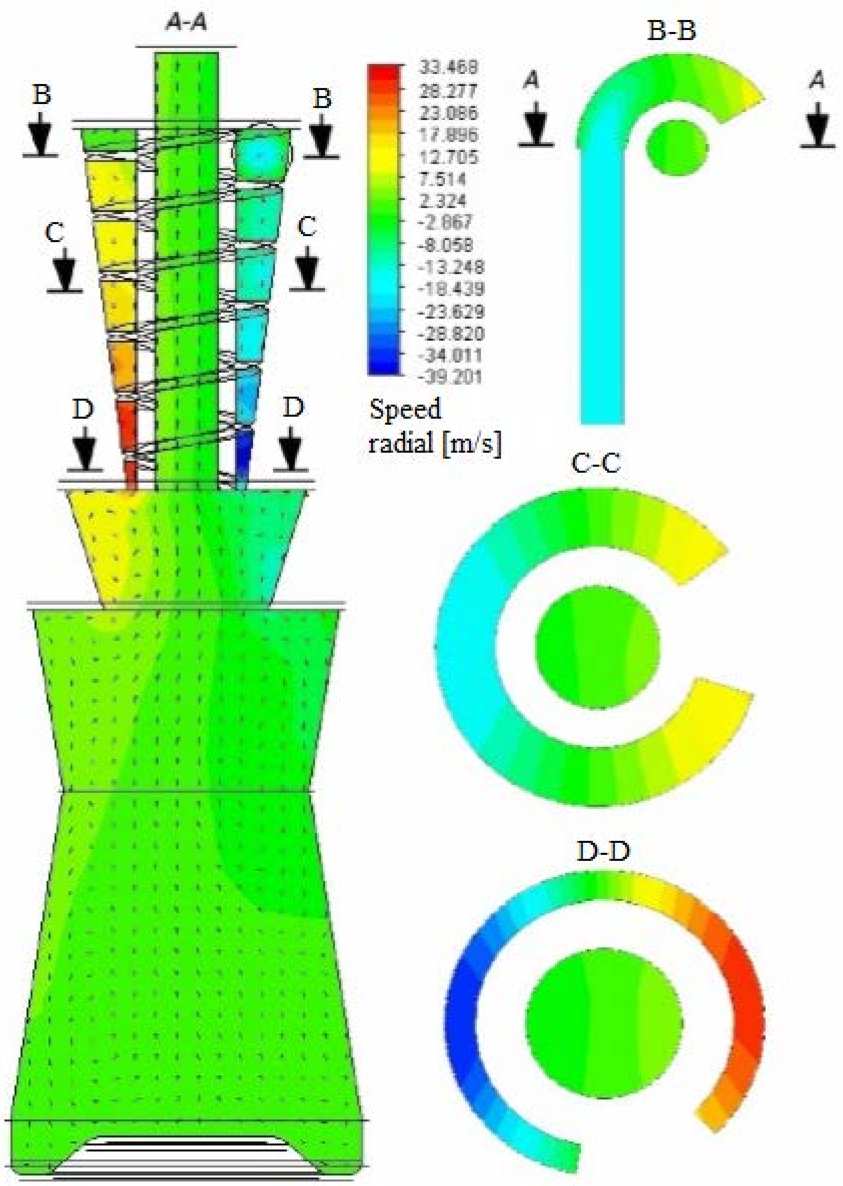


Figure 3. Variation of radial velocity.

Figure 3 shows that the velocity distribution is also not symmetrical and curved. This characterizes that when the air moves through the screw insert, the velocity increases, and the flow is concentrated on the outer wall of the cone. There is a coincidence with the field of dynamic pressure, which corresponds to the fact that this type of speed is predominant in this installation.

The software-hardware complex consists of (Figure 4) a cyclone separator, a Raspberry Pi microcomputer and a client application [8].

A complete model of the information flows of the system for measuring the velocity vector field is shown in Figure 5.

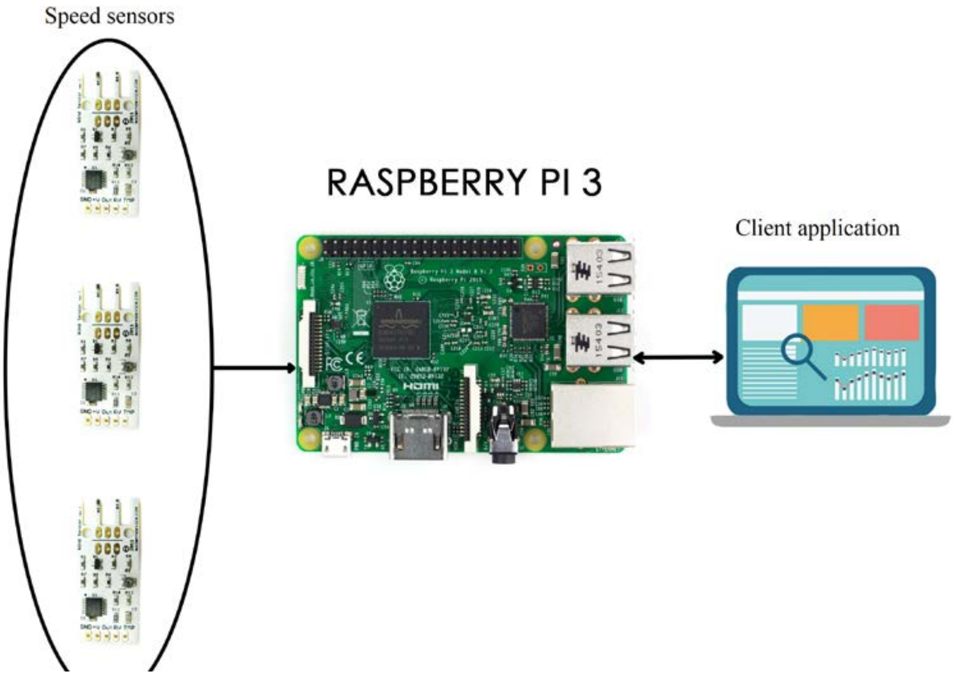


Figure 4. System diagram.

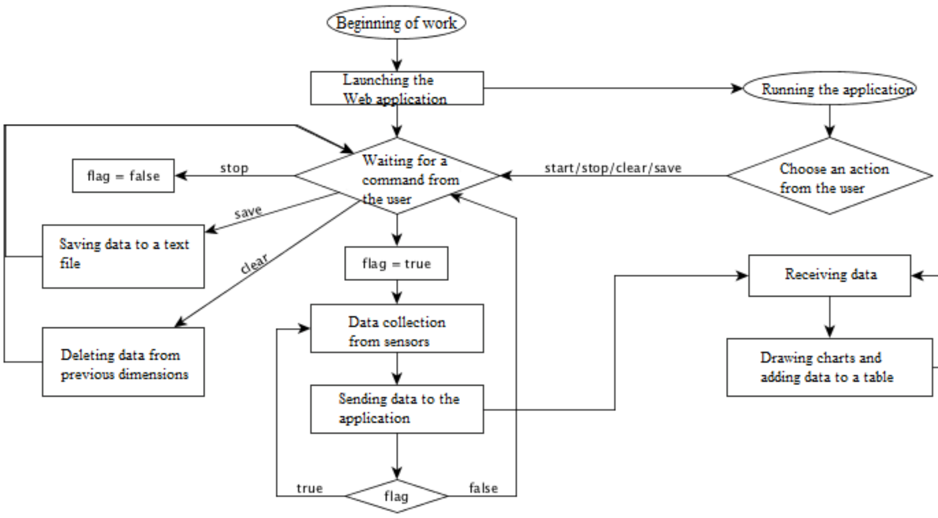


Figure 5. Information flows.

The software-hardware complex works as follows [9, 10]:

- after launching the application by the user, provided that the whole system is working properly, the server application and the client part will be launched, which will be available in the localhost: 3000;
- further the user selects the action that he wants to perform - start the system, stop, save the data in a text file for further processing or clear all data. At the first moment of the start it makes sense to choose the launch, which the user is allowed and selected at the moment;
- the command comes to the server, the server starts to collect data from five wind sensors and store them for further storage and send it to the client application for graphical representation;
- the client application receives data, first processes it, and then adds a new row to the table and new data to the graphs;

- in this mode, the application will work until the user stops the system by pressing the stop button. When he does this, a request for a stop will be sent to the server. All data is saved, only the receipt of new data stops;
- then, the user has a choice, either wipe the data, or save them. If the data is not overwritten, and run another experiment, the new data will be added to the old one.

Figure 6 shows the graphs of the dependence of the speed obtained from the wind sensors on time.

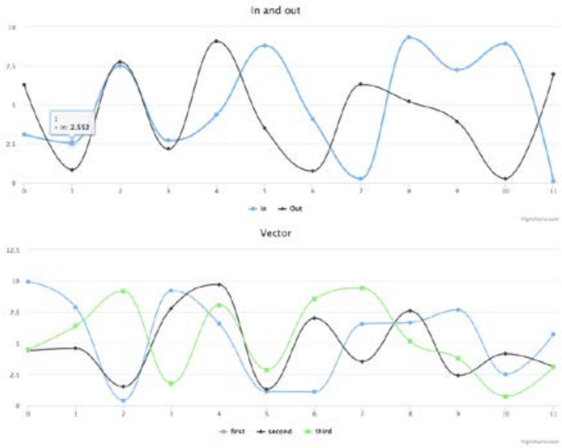


Figure 6. Graphs of the velocity vector field.

Conducted laboratory tests using the software-hardware complex for a cyclone separator showed very satisfactory results both in terms of efficiency and in the aerodynamic resistance of the cyclone. On flour dusts, the efficiency of the cyclone separator in question exceeded 99.5%, with an air flow rate of 376 m^3 / h, 472 m^3 / h and 516 m^3 / h, and ΔP less than 600 Pa. The velocity in the inlet branch of the screw insert was 18–20 m / s, and at the exit of the screw insert the airflow velocity is 50–70 m / s.

4 Conclusion

When comparing the model in SolidWorks and the data obtained with the software-hardware complex, it can be concluded that the discrepancy in the results is not more than 1%. Using modern means of automation, it is possible for 10 - 15 years to extend the life of technological equipment. But the main thing is that without modern automatic control systems, it is impossible to guarantee the quality of the products.

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